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ORIGINAL PAPER

Swedish private forest owners' perceptions and intentions with respect to adopting exotic tree species

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Abstract Swedish forest growth can be increased through intensive forestry practices, enabling an increased use of forest biomass for climate-change mitigation. However, the diffusion of such practices depends on the forest owners' adoption of them. We study Swedish private forest owners' perceptions and intentions with respect to increasing forest growth by adopting exotic tree species. The results of a mail-in questionnaire survey show that although a majority of forest owners desire increasing forest growth, most owners have only a basic understanding of exotic tree species and a smaller proportion is interested in adopting them. The intention to adopt exotics seems to depend on the perceived performance of the species with respect to the economic aspects of forest management rather than on environmental or recreational concerns. Whereas a knowledge gap among the private forest owners regarding how to increase forest growth is implied, forest owners with higher self-rated knowledge of forestry and exotics have stronger intentions to adopt such species.

Keywords Private forest owners · Intensive forestry · Perceptions · Exotics · Sweden

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Introduction

The demand for forest biomass-based products and fuels for climate-change mitigation is expected to increase during the coming decades. The parallel increased demand for the protection of biodiversity, cultural environments and recreational opportunities makes balancing multiple forest goals increasingly difficult (Young et al. 2005; Anon 2006; Bergseng and Vatn 2009). One way to meet the increased demand for biomass is to increase growth in forest areas that are assessed to have a low value with respect to biodiversity, cultural environments and recreation. In 2008, the Swedish government commissioned the Swedish University of Agricultural Sciences (SLU) to investigate and propose forestry practices that increase forest production and future harvest levels (Larsson et al. 2009). The suggested intensive forestry practices include the cultivation of exotic tree species and clones and increased fertilisation. These practices shorten rotation periods while other management practices, such as thinning and clearing, remain the same as in traditional forestry. If applied to 15 % (3.5 million hectares) of Sweden's total productive forest area, intensive forestry practices could increase the annual yield from 30 to 60 million cubic metres of stem wood within 100 years (Fahlvik et al. 2009). However, the realisation of that increase depends on the forest owners' adoption of such practices. Although biomass production and economy may be improved, intensive forestry practices may affect other forest functions of value to the forest owners.

Approximately 50 % of the forest area in Sweden is owned by non-industrial private forest owners (hereafter referred to as 'private forest owners') (Statistics Sweden 2008). Private forest owners are a large and diverse group. Compared with industrial forest owners, they generally invest less in forestry, manage the forest less intensively

and are more influenced by non-economic motives such as recreational opportunities or biodiversity concerns in their forest management (Arano and Munn 2006; Ingemarson et al. 2006; Joshi and Arano 2009). Swedish private forest owners have been categorised into 'economists', who emphasise economic efficiency in forest management, 'conservationists' and 'passive' owners, who are not motivated by profitability and 'multi-objective' and 'traditionalist' owners, who are motivated by several distinct objectives (Ingemarson et al. 2006). Although increasingly fewer private forest owners depend on an income from forestry (Statistics Sweden 2008), most owners seem to belong to the 'economist' group (Ingemarson et al. 2006) and a majority view timber as the most important forest product (Bergseng and Vatn 2009). Thus, while non-economic objectives may motivate many private forest owners, economic returns may remain important in their decision making (Koontz 2001).

The private forest owners' management decisions seem to vary according to several variables including estate size and the forest owners' income, age, education level and the proximity of the owners' place of residence to the forest estate (Koontz 2001; Beach et al. 2005). For example, the likelihood to engage in harvesting activities increases with increasing size of the forest estate (Lidestav and Ekström 2000; Rämö et al. 2009) and decreases with age (Lidestav and Ekström 2000; Favada et al. 2007; Joshi and Arano 2009; Rämö et al. 2009). Older owners are described as more risk-averse than younger ones (Lönnstedt and Svensson 2000; Andersson and Gong 2010). Further, the perceived outcome of different management options influence the forest owners' management decisions. For instance, studies have found that private forest owners' concerns regarding loss of soil fertility influence their interest to sell forest biomass for bioenergy (Bohlin and Roos 2002; Rämö et al. 2009) and that their beliefs about the outcome of natural reforestation influence the choice of reforestation method (Karppinen 2005). Regarding intensive forestry, interviews of different forestry stakeholders, including private forest owners, indicate scepticism of the financial gains involved as well as negative attitudes with respect to the impact on environmental and recreational values (Lindkvist et al. 2012). Such perceptions may influence the forest owners' intention to adopt intensive forestry practices.

The aim of this study is to empirically investigate Swedish private forest owners' perceptions and intentions with respect to increasing forest growth through adopting the exotic tree species lodgepole pine, Sitka spruce, larch and hybrid aspen. Using a mail-in questionnaire, we assess the forest owners' beliefs regarding the outcomes of cultivating the exotics, measure their attitudes towards the exotics using the multi-attribute attitude model (Hawkins et al. 2007) and analyse how the attitudes and the forest owners' knowledge and perceived behavioural control may influence their intention to adopt exotic tree species.

Exotic tree species in Swedish forestry

Silviculture has long favoured fast-growing and easily managed indigenous conifers. Therefore, most forested land area in Sweden is dominated by Norway spruce and Scots pine (Knight et al. 2001). The cultivation of exotics has been limited. In the 1970s, a predicted timber shortage resulted in large plantations of lodgepole pine (indigenous to North America), which exhibits timber qualities comparable with or better than Scots pine, but environmental concerns and problems with pathogens and tree instability led to restrictions and a decrease in planting (Elfving et al. 2001; Engelmark et al. 2001; Karlman 2001). In 2001, 2.5 % of the productive forest land was occupied by lodgepole pine, most planted in company-owned forests (Elfving et al. 2001). Present law restricts the species to specific altitudes in areas north of the 60th parallel except in two counties (Örebro and Värmland) and a national maximum of 14,000 ha per year may be regenerated with lodgepole pine. However, the SLU (Larsson et al. 2009) concluded that the species has been tested sufficiently to be reintroduced on a larger scale in Swedish forestry. This is also the case with the deciduous hybrid aspen. The hybrid aspen is currently limited to experimental plantations (Larsson et al. 2009) but was cultivated in Sweden during the 1940s to the 1960s for the production of matches (Christersson 1996). The species is considered appropriate for pulpwood and bio energy (Karacic 2005). Present regulations regarding the hybrid aspen are vague, but the Swedish forest agency recently recommended that the tree be considered an exotic (Skogsstyrelsen 2009).

Siberian or Russian larch is considered an indigenous Swedish conifer appropriate for northern Sweden, but the tree has not occurred naturally since directly after the last ice age (Karlman 2010). Experimental plantations have shown promising results with high biomass production (Larsson et al. 2009). However, larch contributes to less than 1 % of the total standing volume in Sweden, of which the majority is in the south (Larsson-Stern 2003) where a hybrid crossbreed between European and Japanese larch is considered more suitable (Larsson et al. 2009). Larch wood generally produces durable timber with high density and a high volume of heartwood (Karlman 2010). The North-American Sitka spruce is another alternative high-yield conifer suitable for the climate of south-western Sweden which possesses wood qualities similar to Norway spruce (Tengberg 2005). Sitka spruce is cultivated on a large scale and with a high yield in Norway and Denmark (Karlsson

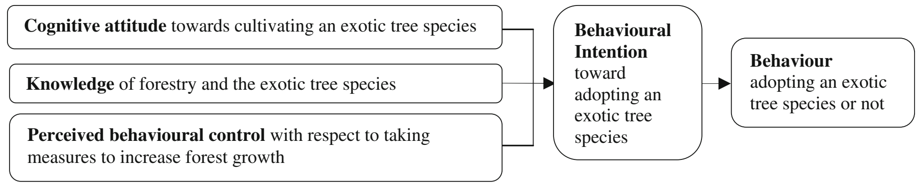

Fig. 1 Overview of the theoretical framework of the study [adapted from Ajzen (2005)]

2007) but has not been introduced in Swedish forestry. Because of the limited experience with larch and Sitka spruce in Sweden, these trees are not considered appropriate for large-scale plantations. Under the present legal restrictions, the regeneration of larch and Sitka spruce is limited to 0.5 ha per management unit without notification to the authorities (Larsson et al. 2009).

Introducing exotics includes uncertainties and is largely a matter of balancing opportunities and risks. The self-dispersal of the species to new environments, the spread of pathogens and pests to native systems and ecosystems and changes to ecosystem processes, structure and biodiversity are some risks associated with the introduction of exotics (Engelmark et al. 2001; Karlman 2001). In addition, the implementation of more intense forest management practices may negatively influence the cultural environment and recreational opportunities (Larsson et al. 2009). Still, a recent review of current forestry regulations by the Swedish forest agency recommended that exotics should be allowed to a larger extent, primarily because of the opportunity to produce more forest raw materials and adapt to climate change (Skogsstyrelsen 2009). The general recommendation by the SLU (Larsson et al. 2009) is to revise the regulations on intensive forestry practices as the knowledge of their consequences increases.

Method

Theory

Because the majority of exotic tree species remain subject to regulatory restriction and are expected to be new or unknown to many forest owners, the question of them adopting exotics is primarily hypothetical and refers to the forest owners' behavioural intention, not the actual behaviour of cultivating the exotics. The theory of planned behaviour (Ajzen 2005) stipulates that an individual's behavioural intentions (and thus behaviours) are a function of three basic determinants: the individual's cognitive attitude[1] (positive or negative evaluation of the outcomes) towards the behaviour (e.g. towards increasing forest growth through adopting an exotic tree species); the individual's perception of the social pressure to perform or not perform the behaviour (subjective norm); and the perceived behavioural control (the sense of one's ability to perform the behaviour, e.g. to increase forest growth by learning more about forest management practices). Perceptions may be accurate or inaccurate with respect to objective reality but perceptions rather than reality determine behaviour (Rogers 2003; Hawkins et al. 2007). Following from this theory, the forest owners' intentions to adopt exotics likely depend on their evaluation of the outcome of cultivating such species and whether they perceive them to fit with their management goals. However, whereas attitudes and perceived behavioural control have been found to correlate strongly with actual behaviour, the subjective norm often explains less variance in the behavioural intentions (Ajzen 2005) and is not investigated in this study. Instead, as potential adopters' level of knowledge influences their adoption decisions (Rogers 2003), we investigate if the forest owners' self-rated knowledge of forestry and the exotics influence their intentions to adopt exotics. An overview of the study's theoretical framework is provided in Fig. 1.

Survey questionnaire

A mail-in questionnaire was used to collect information on Swedish private forest owners' perceptions and intentions with respect to cultivating exotic tree species. Statistics Sweden administered the sampling, the mailing of the questionnaires and the collection of the data.

The private forestry of Sweden comprises 240,742 management units distributed among 335,805 private forest owners (Statistics Sweden 2008). The sample frame (the population from which the sample was extracted) of the study was determined according to the Swedish register of property assessment and included only physical persons with Swedish personal identity numbers and Swedish addresses. Undistributed estates of deceased persons were

[1] Attitudes are considered to possess the three components: affective (emotions or feelings), cognitive (beliefs) and behavioural (response tendencies). This paper primarily evaluates the *cognitive* component of attitudes, which consists of perceptions (beliefs or knowledge) of the attributes of a phenomenon (e.g. how an exotic tree species performs with respect to forest growth). Although the other components of forest owner attitudes are not analysed here, all three components of an attitude are generally consistent (Hawkins et al. 2007).

excluded, as were owners of less than 10 ha of forest, who were assumed to have little capacity to invest in intensive forestry. In the case of several owners of a management unit, the owner responsible for the income-tax return of the estate was chosen. The sample frame included 142,115 individuals. A stratified simple random sample of 3,000 individuals was extracted from this population on a national level, followed by an additional sample of 500 individuals in parts of northern Sweden because of a regional interest in the research project. The national sample was proportionally stratified based on the size of forest estate and the NUTS (nomenclature of territorial units for statistics) regions of the owners' residency, whereas the additional sample was proportionally stratified based on the size of the forest estate(s). Statistics Sweden merged the samples and provided information on the respondents' age, gender, forest estate(s) size and NUTS region.

The study questionnaire consisted of seven parts. Most questions included five-point Likert-type scales (e.g. 1 = Completely disagree, 5 = Completely agree). The naming of the extremes of the scales depended on the question. In addition to questions on general forest management and the use of exotics, the questionnaire addressed the afforestation of arable land and forest fertilisation. Questions relevant to the analysis of this study are described in the "Method" section.

Questionnaires were sent in January 2010. The cover letter included information on the background and purpose of the study and contact information of the responsible individuals. Two reminders followed, which were sent 2 weeks after the previous mailing. The second reminder included an additional copy of the questionnaire. In total, 1,465 respondents completed the questionnaire. One hundred and five individuals were excluded from the sample because of postal returns, emigration, illness, sale of the forest or death, and 83 individuals were unwilling to participate in the survey. The response rate of 43 % is below that of some earlier studies [see, e.g. Andersson and Gong 2010; Ingemarson et al. 2006] but equal to or higher than others [see, e.g. Arano and Munn 2006; Blennow and Sallnäs 2002; Rämö et al. 2009]. Possible reasons for non-participation include an uninteresting survey topic, survey fatigue in the target group and the length and complexity of the questionnaire. The survey topic was likely to be particularly uninteresting to owners who have little interest in forest management. A screening of socio-demographic variables indicated that the response rate was lower among owners aged 54 and younger and higher among owners over 64 years of age (Table 1). In addition, the response rate was lower among women than among men. Thus, the data were skewed towards older men. However, with respect to other screened variables, the respondents were considered representative for the chosen population. The potential influence of the additional sampling in northern Sweden is discussed in the "Discussion" section.

Table 1 Distribution of sample frame, sample, respondents and response rate with respect to size of forest estate(s), age and gender

	Sample frame	Sample size	No. of respondents	Percentage of total respondents	Response rate (%)
Size of estate(s) (hectares)					
10–19	34,519	825	320	22	39
20–49	49,691	1,190	500	34	42
50–99	31,339	773	326	22	42
100–	26,566	713	316	22	44
Age (years)					
≤44	19,332	489	145	10	30
45–54	29,982	763	267	18	35
55–64	41,709	965	441	30	46
≥ 65	51,092	1,229	609	42	50
Gender					
Female	–	945	341	23	36
Male	–	2,556	1,121	77	44
Total	142,115	3,501	1,465	100	43

Analysis

Because the aim of the study was to investigate factors that influence the intention to adopt exotic tree species, only the respondents who were willing to increase forest growth in their present forest (79 % of $n = 1{,}389$) were included in the analysis. These respondents rated their agreement (1 = Completely disagree, 5 = Completely agree) with the statement that they can increase forest growth by learning more about what is suitable for their forest, which indicated their perceived behavioural control (PBC) with respect to adopting measures to increase forest growth. For other predictors included in the analysis, multiple questions measuring similar things were posed from which new variables were prepared. The forest owners' behavioural intention towards adopting an exotic tree species was indicated by the sum of the respondents' rated interest (1 = Not interested at all, 5 = Very interested) in cultivating an exotic and the rated agreement (1 = Completely disagree, 5 = Completely agree) to being open to new suggestions on how to increase forest growth. A similar procedure was used to establish a variable representing the forest owners' level of knowledge, where the self-rated knowledge (1 = Do not know at all, 5 = Know very well) of each species was added to the self-rated general knowledge (1 = Do not know at all, 5 = Know very well) of forestry.

To determine which attributes of forest management that the forest owners prioritise, the respondents were asked to rate the importance (1 = Not important at all, 5 = Very important) of different consequences for the forest management (e.g. how important is the landscape scenery, the timber supply, or biodiversity) of their productive forest. Then, the respondents rated the performance (1 = Poor performance, 5 = Good performance) of each species with respect to the consequences (e.g. how well lodgepole pine performs with respect to the landscape scenery), which revealed the forest owners' beliefs about the exotic tree species. There were 19 consequences for which the respondents rated the importance. Not all of the consequences could be included in the regression analysis (to maintain enough observations for each variable). Therefore, factor analysis[2] using the principal component extraction method was employed to derive a smaller number of underlying factors. The factor analysis revealed the three factors: economic (ECO), environmental (ENV) and recreational (REC) (see Table 2). The economic factor included economy- or production-related consequences for forest management (Cronbach's $\alpha = 0.90$, 11 items). The environmental factor included various environmental consequences for forest management (Cronbach's $\alpha = 0.84$, 3 items), whereas the recreational factor included consequences related to the recreational uses of forests (Cronbach's $\alpha = 0.79$, 5 items). The three factors together explained 59 % of the variance in the importance rating ($p \leq 0.001$).

The forest owner's economic, environmental and recreational cognitive attitudes towards each exotic tree species were then estimated using the multi-attribute or the Fishbein model (see Eqs. 1–3), which is frequently used to determine customer attitudes towards brands (Hawkins et al. 2007). This model accounts for both the weight given to a certain attribute (e.g. importance of landscape scenery in the forest management) and the evaluation of the attitude-object with respect to that attribute (e.g. how lodgepole pine performs with respect to the landscape scenery).

$$A_s^{ECO} = \sum_{c=1}^{n} I_c^{ECO} P_{cs}^{ECO} \quad (1)$$

$$A_s^{ENV} = \sum_{c=1}^{n} I_c^{ENV} P_{cs}^{ENV} \quad (2)$$

$$A_s^{REC} = \sum_{c=1}^{n} I_c^{REC} P_{cs}^{REC} \quad (3)$$

[2] Factor analysis is based on the assumption that all variables are correlated to a certain degree. Variables that are correlated with one another but largely independent of other subsets of variables are combined into factors (Tabachnick and Fidell 2006).

Table 2 Results of the factor analysis of the rated importance (1 = Not important at all, 5 = Very important) of different consequences of forest management according to the size of the loadings with which the variables contribute to the factors

Importance of	Factor		
	Economic (ECO)	Environmental (ENV)	Recreational (REC)
Timber supply	**0.833**	−0.026	0.097
Timber quality	0.787	0.010	0.118
Growth	**0.767**	0.001	0.049
Profitability	0.764	0.191	−0.056
Soil nutrients	0.671	0.402	0.070
Vulnerability snow/storm damage	**0.660**	0.450	0.021
Pulpwood supply	0.628	−0.001	0.180
Vulnerability game damage	0.600	0.383	−0.015
Value of forest for coming generations	**0.565**	0.271	0.173
Vulnerability fungi/insect attacks	0.536	0.497	0.036
Public benefits	0.478	0.338	0.226
Climate impact	0.143	**0.808**	0.206
Nitrogen leakage	0.221	**0.803**	0.217
Biodiversity	0.086	**0.616**	0.481
Recreation/outdoor activities	0.045	0.153	**0.827**
Berry picking/mushrooms	0.078	0.206	**0.792**
Landscape scenery	0.046	0.314	**0.708**
Hunting	0.317	−0.136	**0.578**
Cultural environment	−0.021	0.513	**0.573**

Values in bold represent the variables kept in each factor for the following analyses

where A_s^{ECO}, A_s^{ENV} and A_s^{REC} are the economic, environmental and recreational attitudes (A) of a respondent towards each exotic tree species s, s = lodgepole pine, Sitka spruce, larch and hybrid aspen; I_c^{ECO}, I_c^{ENV} and I_c^{REC} are a respondent's rating of the importance (I) of the consequences of forest management (c) included in the economic, environmental and recreational factors (derived from the factor analysis), respectively; and P_{cs}^{ECO}, P_{cs}^{ENV} and P_{cs}^{REC} are the beliefs of a respondent about the performance (P) of species s with respect to consequence c of the forest management included in the economic, environmental and recreational factors, respectively.

For example, one respondent rated the importance (1 = Not important at all, 5 = Very important) of the environmental consequences of forest management (I_c^{ENV}) as follows: biodiversity 4, nitrogen leakage 1 and climate change 4. The same respondent rated the performance

(1 = Poor performance, 5 = Good performance) of lodgepole pine with respect to the environmental consequences of forest management ($P^{ENV}_{c-lodgepole\,pine}$) as follows: biodiversity 3, nitrogen leakage 2 and climate change 4. Thus, the respondent's importance rating of environmental consequences (I^{ENV}_{c}) is 3 [(4 + 1 + 4)/3], the respondent's average performance rating of lodgepole pine with respect to environmental consequences ($P^{ENV}_{c-lodgepole\,pine}$) is 3 [(3 + 2 + 4)/3] and the respondents attitude towards lodgepole pine with respect to environmental consequences ($A^{ENV}_{lodgepole\,pine}$) is 30 [(4 × 3) + (1 × 2) + (4 × 4)]. A higher number indicates a more favourable attitude. The average importance and performance ratings and the attitudes towards the other species and with respect to the other factors (economic and recreational) could be estimated accordingly (see comparisons of the resulting attitudes towards the different species in the "Results" section).

A large number of respondents failed to answer or answered 'do not know' (treated as missing values) when asked to rate the performance of the exotics with respect to the consequences of forest management.[3] This result decreased the number of observations included in the attitude equations, most notably with respect to the economic factor (A^{ECO}_{s}) of the exotics. To decrease the number of missing answers (see the "Missing answers" section for more about missing answers), only four consequences were retained in the economic factor. The chosen consequences (marked with boldface in Table 2) had the maximum number of observations while continuing to correlate strongly with the factor and were considered representative for the economy or the productivity of the forest management (Cronbach's α = 0.76).

Regression models

To understand the relative predictive power of the cognitive attitudes, knowledge and perceived behavioural control with respect to the intention to adopt an exotic tree species, a multiple regression analysis was used. The intention towards each exotic tree species was tested individually. In addition to the predictors motivated by the theoretical model, the literature review prompted the control for the influence of the socio-demographic variables age, size of forest estate(s), geographical region[4] and educational level (compulsory, upper secondary or university level) on the intention to adopt an exotic. Because of a low number of female respondents, gender could not be included in the analysis. The regression models are expressed as Eq. 4:

$$BI_s = Y + X_1A^{ECO}_s + X_2A^{ENV}_s + X_3A^{REC}_s + X_4K_s + X_5PBC + X_{6-9}SD_{1-4} \tag{4}$$

where BI_s is the (predicted) behavioural intention towards exotic tree species, s = lodgepole pine, Sitka spruce, larch and hybrid aspen; Y is the intercept; X_1–X_9 are the coefficients; A^{ECO}_s, A^{ENV}_s and A^{REC}_c are the attitudes towards the exotic s with respect to the economic, environmental and recreational consequences of forest management; K_s is the knowledge of forestry and the exotic s; PBC is the perceived behavioural control; and SD are the socio-demographic variables.

Missing answers

Because the regression and multi-attribute models exclude missing and 'do not know' answers list-wise, the combination of variables included in the regression equations significantly decreased the number of respondents. In the regression equation for Sitka spruce, 153 observations were included, whereas the number of observations was 238 for lodgepole pine, 197 for larch and 185 for hybrid aspen. To assess whether there were differences in the response patterns (e.g. the rated importance of different consequences for forest management) between the respondents who were included in the regression equation and the remaining respondents, the mean values of the variables included in the attitude and regression equations were compared. The nonparametric Mann–Whitney U test was used to test whether the differences were statistically significant ($p \leq 0.05$). The test converts the response scores to ranks and evaluates whether the ranks differ significantly between two distinct groups of respondents. This approach is suitable for testing differences between independent samples of ordinal or continuous data (Pallant 2007). Additionally, the characteristics of the respondents (regarding education, the geographical region and the size of forest estate(s)) included in the regressions were compared with the characteristics of those who were excluded. This comparison was performed through cross-tabulations of the observations for each variable against whether the

[3] In terms of species, the largest number of 'do not know' answers involved Sitka spruce (a mean value for the consequences for forest management of 60 % 'do not know' answers). In terms of consequences for the forest management, the greatest number of 'do not know' answers was regarding performance with respect to nitrogen leakage (a mean value across the species of 60 % 'do not know' answers) followed by performance with respect to vulnerability to insect and fungi attacks (a mean value of 55 %).

[4] The regression equations controlled for whether the respondent resided in Sweden's northern (SE3) NUTS (nomenclature of territorial units for statistics) region or in the east or south (SE1 and SE2). This division of Sweden follows approximately the 60th parallel.

respondent was included or excluded from the regression equations. Chi-square tests for independence determined whether the associations were statistically significant. Some differences were found ($p \leq 0.05$, see results in the "Comparison of respondents" section).

Results

The survey respondents rated the economy factor as the most important to their forest management, followed by the recreational and environmental factors (Table 3). Hybrid aspen and larch were on average perceived to perform better than the other exotics with respect to the economic factor, whereas the hybrid aspen was perceived as best with respect to both the recreational and the environmental factors. Relative to the other factors, all species received the lowest performance rating with respect to the recreational factor of forest management. The average cognitive attitude (of all of the respondents included in the multi-attribute models) with respect to the economic factor was most favourable towards larch and least favourable towards lodgepole pine. With respect to the recreational and environmental factors, the average attitudes were most favourable towards hybrid aspen and least favourable towards Sitka spruce. The rated knowledge of forestry and the exotics was on average low. It was highest for lodgepole pine and lowest for Sitka spruce (Table 3).

The majority of the respondents were not interested in cultivating the exotics. The largest interest was in cultivating larch (22 % rated a 4 or 5 on an interest scale of 1 = Not interested at all, 5 = Very interested, $n = 982$), followed by hybrid aspen (19 % interested, $n = 961$). The least interest was in lodgepole pine. The mean behavioural intention followed the same pattern: highest towards larch and least towards lodgepole pine (Table 3).

Predicting behavioural intentions

Table 4 presents the results of the regression equations of the behavioural intention towards adopting the exotics. The Beta value for a particular predictor represents the change in the behavioural intention associated with a one-unit change in the predictor, all other predictors held constant (Tabachnick and Fidell 2006). Regarding the cognitive attitudes, the Beta values indicate that more favourable

Table 3 Mean rated importance of consequences of forest management with respect to the economic (ECO), environmental (ENV) and recreational (REC) factors, mean rated performance of and attitudes towards the exotics with respect to these factors and mean knowledge of and behavioural intention towards adopting the species

Mean	Possible values	All species (n)	Larch (n)	Hybrid aspen (n)	Sitka spruce (n)	Lodgepole pine (n)
Importance[a]						
ECO[b]	1–5	4.24 (1,130)				
ENV[c]	1–5	3.43 (1,092)				
REC[d]	1–5	3.44 (1,117)				
Performance[e]						
ECO	1–5		3.21 (750)	3.22 (728)	3.12 (635)	2.98 (851)
ENV	1–5		3.21 (650)	3.33 (637)	3.12 (589)	3.10 (728)
REC	1–5		2.92 (780)	2.97 (755)	2.73 (701)	2.75 (847)
Attitudes[f]						
ECO	4–100		56.7 (369)	56.2 (334)	56.1 (265)	51.4 (474)
ENV	3–75		34.7 (375)	36.0 (370)	33.5 (347)	33.7 (432)
REC	5–125		50.6 (403)	51.5 (397)	46.1 (354)	46.2 (501)
Knowledge[g]	2–10		5.2 (986)	5.0 (988)	4.7 (989)	5.4 (1,004)
Behavioural intention[h]	2–10		6.3 (858)	6.1 (838)	5.9 (819)	5.8 (836)

[a] Mean rated importance (1 = Not important at all, 5 = Very important) of consequences for forest management included in the specific factors

[b, c, d] See Table 2 for the included consequences

[e] Mean rated performance (1 = Low performance, 5 = High performance) of species with respect to the consequences included in the specific factors

[f] Computed attitudes [see Eqs. 1–3] per species. A higher number indicates a more favourable attitude

[g] Sum of knowledge (1 = Do not know at all, 5 = Know very well) of species and general knowledge (1 = Do not know at all, 5 = Know very well) of forestry

[h] Sum of interest (1 = Not interested at all, 5 = Very interested) in cultivating species and openness (1 = Completely disagree, 5 = Completely agree) to adopting new measures. A higher number indicates a stronger intention to adopt the species

attitudes towards the exotics have a positive effect on the intention to adopt the species. The attitude towards the economic factor of the species had a significant effect on the behavioural intention towards each exotic. In addition, the intention to adopt the hybrid aspen was positively influenced by a more favourable attitude towards the environmental factor of that species. Moreover, the intention to adopt the exotics was positively influenced by the perceived behavioural control, that is, the stronger the belief that growth can be increased through learning more about forest management practices is, the stronger the intention to adopt an exotic. In terms of knowledge, higher knowledge of forestry and the species was positively related to an intention to adopt larch but did not contribute to any significant amount of explained variance in the intention to adopt the other species. Educational level had a significant effect on the intentions to adopt lodgepole pine and larch, where respondents with university education had stronger intentions to adopt these species than the other respondents. However, there was no significant effect of the other socio-demographic variables that were included in the analysis.

In sum, cognitive attitudes, perceived behavioural control, knowledge of the species and educational level explained approximately 40 % of the variance in the intention to adopt the exotics. For example, the regression equation for lodgepole pine suggests that 39 % of the variance in the respondents' intention to adopt that species can be explained by the attitude towards lodgepole pine with respect to the economic factor, the perceived behavioural control and the educational level. Attitudes explained the most variance in the intention to adopt the exotic tree species, followed by the perceived behavioural control. The equations showed no signs of multicollinearity or heteroscedasticity and the F-statistics indicated a good model fit.

Comparison of respondents

The comparisons of respondents included in the regression equations and the remaining respondents (who did not answer or answered 'do not know' to the included questions) revealed certain differences. The respondents included in the regression equations possessed stronger intentions to adopt exotics than the other respondents (Table 5). Additionally, the respondents included in the regression equations had significantly higher levels of self-rated knowledge of forestry and the exotics. There were no significant differences between the respondents included in the regression equations and the other respondents regarding the rated importance of the economic, environmental and recreational factors for forest management or the perceived behavioural control. In addition, the relative importance of the factors was the same, as was the relative

Table 4 Results of the multiple regression equations [see Eq. 4] of the influence of respondents' attitudes, perceived behavioural control, knowledge and characteristics on the behavioural intention to adopt exotic tree species, expressed in Beta values (coefficient of variables)

Predictors	Behavioural intention towards[a]			
	Larch ($n = 197$)	Hybrid aspen ($n = 185$)	Sitka spruce ($n = 153$)	Lodgepole pine ($n = 238$)
Attitude ECO[a]	0.379***	0.327***	0.364***	0.297***
Attitude ENV[a]	0.027	0.216**	0.050	0.058
Attitude REC[a]	0.062	0.002	0.112	0.048
Perceived behavioural control[b]	0.350***	0.277***	0.381***	0.396***
Knowledge[a]	0.122*	0.099	0.057	0.062
Size of estate(s)[c]	−0.036	0.059	0.085	0.070
Age	−0.005	0.031	0.020	−0.013
Education[d]	0.180**	0.108	0.027	0.149**
Geographical region[e]	−0.013	−0.049	−0.086	−0.002
Adj. R^2	0.426***	0.359***	0.374***	0.394***

Asterisks indicate the significance of the explanatory power of the predictor variables. *** $p \leq 0.001$, ** $p \leq 0.01$, * $p \leq 0.05$

R^2, the squared multiple correlation, is the proportion of variation in the behavioural intention predictable from the best linear combination of the predictors. Adjusted R^2 considers the magnitude of chance fluctuations as a result of the sample size (Tabachnick and Fidell 2006)

[a] See explanation of variable in Table 3

[b] Agreement (1 = Completely disagree, 5 = Completely agree) to being able to increase forest growth by learning more about forest management

[c] 1 = 1–19 ha, 2 = 20–29 ha, 3 = 50–99 ha, 4 = 100 or more hectares

[d] 1 = Compulsory school, 2 = Upper secondary school, 3 = University level education

[e] 0 = South or East region of Sweden, 1 = North region of Sweden

Table 5 Response patterns of respondents included (Incl.) in regression equations versus those excluded (Excl.). Comparisons are regarding the importance of the economic (ECO), environmental (ENV) and recreational (REC) factors, the rated performance of the species with respect to those factors, self-rated knowledge of forestry and the species and behavioural intentions

Mean	Larch[a]		Hybrid aspen[a]		Sitka spruce[a]		Lodgepole pine[a]	
	Incl. (*n*)	Excl. (*n*)	Incl. (*n*)	Excl. (*n*)	Incl. (*n*)	Excl. (*n*)	Incl. (*n*)	Excl. (*n*)
Importance								
ECO	4.29 (197)	4.23 (933)	4.29 (185)	4.23 (945)	4.28 (153)	4.23 (977)	4.29 (238)	4.22 (892)
ENV	3.51 (197)	3.41 (895)	3.53 (185)	3.41 (907)	3.48 (153)	3.42 (939)	3.50 (238)	3.41 (854)
REC	3.51 (197)	3.42 (920)	3.46 (185)	3.43 (932)	3.50 (153)	3.43 (964)	3.50 (238)	3.42 (879)
Performance								
ECO	3.31 (197)	3.18 (553)	3.25 (185)	3.21 (543)	3.29 (153)*	3.06 (482)	3.03 (238)	2.95 (613)
ENV	3.27 (197)	3.19 (453)	3.37 (185)	3.32 (452)	3.21 (153)	3.09 (436)	3.20 (238)	3.05 (490)
REC	3.01 (197)	2.89 (583)	3.03 (185)	2.96 (570)	2.71 (153)	2.74 (548)	2.69 (238)	2.77 (609)
Knowledge	6.38 (197)*	4.84 (789)	6.16 (185)*	4.69 (803)	5.95 (153)*	4.50 (836)	6.45 (238)*	5.07 (766)
Behavioural intention	6.88 (197)*	6.12 (661)	6.89 (185)*	5.90 (653)	6.71 (153)*	5.76 (666)	6.21 (238)*	5.64 (598)

[a] An asterisk indicates a Mann–Whitney *U* test found the respondents included in the regression equation provided a significantly higher rating of the variable than the excluded respondents ($p \leq 0.05$)

performance rating of all of the species with respect to the factors. The respondents included in the regression equation for Sitka spruce provided a significantly higher performance rating of the species with respect to the economic factor compared with the respondents excluded from the equation.

The mean age was somewhat lower among the respondents included in the regression equations (57–58 years depending on species) than among the other respondents (62 years). Additionally, a higher proportion of respondents included in the equations had university education. Regional differences were also observed. Compared with the excluded respondents, those included in the regression equations for lodgepole pine were more likely to reside in northern Sweden than in the east or south. Contrary, the respondents included in the regression equations for Sitka spruce, larch and hybrid aspen were more likely to reside in southern or eastern Sweden than in the north compared with the respondents excluded from the equations.

Discussion

Although a majority of Swedish private forest owners desire increasing forest growth, the results of this study show that most of them have a limited understanding of exotics and do not intend to adopt exotic tree species. The regressions imply that the forest owners' intentions to adopt exotics depend on their attitudes towards the species. Because the attitudes studied here are a function of two different variables (the importance awarded to certain consequences of forest management and the belief regarding how the exotic would perform with respect to that aspect), one way of influencing the potential adoption of exotic tree species may be to inform forest owners how the species perform with respect to what the owners find highly important to their forest management: aspects related to forest production and the economy. This approach may change their perceptions. This approach may also be applicable to the respondents not included in the regressions since they gave similar rating to the importance of different consequences of the forest management and held similar beliefs regarding the performances of the exotics.

Similar to the result of Rämö et al. (2009) with respect to Finnish forest owners' intention to supply biomass for bio-energy, uncertainties regarding environmental and recreational aspects do not seem to influence the intention to adopt exotics. However, the intention to adopt hybrid aspen would be stronger if the forest owners thought the species would perform better with respect to environmental aspects. This corroborates previous studies indicating forest owners find both economic and environmental aspects of their forest management important (Nordlund and Westin 2011) and may perceive intensive forestry to negatively impact environmental values (Lindkvist et al. 2012).

The respondents who could be included in the regression equations were few but did not differ from other respondents with respect to their beliefs. They mainly differed with respect to knowledge. The majority of respondents seemed to possess a low level of knowledge of the exotics in general and the various consequences in particular. This insufficient knowledge suggests that the need for

information on exotic tree species is large. In addition, the high number of private forest owners who desire to increase growth suggests that many have the need but lack the know-how.

A higher self-rated knowledge of forestry and the exotics implied stronger intentions to adopt the exotics. The effect of knowledge was only significant in the regression equations for larch, which suggests that improved knowledge of forestry and the species would not significantly affect the behavioural intention towards adopting the other species. However, the respondents included in the regression equations on average rated a higher level of knowledge than those excluded and exhibited stronger behavioural intentions towards adopting these three species. This outcome implies that the perceived knowledge of forestry and the species affects the behavioural intention. Not having sufficient knowledge, the practices may be associated with much risk.

That the private forest owners may experience a knowledge gap regarding how to increase forest growth is further implied by the fact that the intention to adopt exotics related to a belief that forest growth may be increased through an improved understanding of forest management (referred to as the perceived behavioural control). However, this result also implies that those who are not interested in exotics do not believe that they can increase growth through improved knowledge. Possible reasons may be that that these forest owners do not believe that forest growth can be increased or that they already feel sufficiently knowledgeable.

The low interest in lodgepole pine (of which the knowledge was higher) may be partly explained by earlier introductions of lodgepole pine in Swedish forestry, through which forest owners may have formed negative perceptions of the species. The performance of lodgepole pine was generally perceived as the poorest, whereas the 'do not know' answers were fewer than for the other exotics. Because there was a larger representation of forest owners from northern Sweden, where people seemed more informed about lodgepole pine (exhibited in the higher prevalence of northern respondents in the regression equation for the species), the national interest in and intention to adopt the species may be less than the results indicate. The respondents from northern Sweden may be more familiar with lodgepole pine because of the comparatively large standing volume of the species in the region (Skogsstyrelsen 2009). Still, contrary to Lindkvist et al. (2012), this study did not find any significant influence of geographical region on the forest owners' intention to adopt exotics.

In contrast to the 'economist' private forest owners (Ingemarson et al. 2006) and Finnish owners interested in forest fuels (Rämö et al. 2009), the intention to adopt exotics among the respondents to this study was not related to younger age or to the larger size of the forest estate. However, because the respondents included in the regression, which were significantly younger than the rest of the respondents, had stronger intentions to adopt exotics than the other respondents did, a correlation with age may exist. The topic of the survey may have attracted forest owners with an interest in forest growth. However, the mean age among the private forest owners is generally high and the data skewed towards older males. Thus, the overall results are influenced by the perceptions of older, possibly more risk-averse (Andersson and Gong 2010) forest owners. Considering the long rotation periods in forestry, these owners may be less likely to invest in new practices because they plan to leave the forest for the next generation.

The aim of this study was to measure private forest owners' intentions and beliefs regarding exotics irrespective of their knowledge level. Because the exotics investigated in this study remain under regulatory restriction, no government policy to encourage private forest owners to adopt them has been developed. However, Swedish private forest owner organisations cooperate with the federation of Swedish farmers in the 'Focus on forestry' initiative to educate and encourage their members to increase profitability through increased forest growth (Anon 2010a), for example through improved forestry knowledge or better planning of current forest management practices. The initiative includes information on exotics (Anon 2010b). However, there seems to be a need for information on the outcomes of such practices. For agencies that aim to increase forest growth through the cultivation of exotic tree species, information on how the exotics perform with respect to the economic aspects of forest production may be most effective.

These results show that interest in and intentions to adopt exotic tree species exist. However, the model employed in this study only explained part of the intention to adopt an exotic, and it likely depends on more variables than included here. For instance, Nordlund and Westin (2011) found that Swedish forest management attitudes are influenced by basic and environmental values as well as forest values and forest-specific beliefs. Furthermore, an intention to adopt an exotic does not necessarily result in an actual implementation. However, favourable cognitive attitudes towards the exotics are most likely a precondition for the adoption, and attitudes have been found to possess a strong explanatory power with respect to intentions in previous studies [see, e.g. Karppinen 2005].

The questionnaire used in this study was designed for multiple purposes. A shorter and less-complicated survey focused only on the use of exotics may result in a higher response rate and fewer missing answers. Moreover, the list of consequences for forest management included in the questionnaire and analysis was based on a literature review.

Therefore, it was difficult to narrow the list because it was unclear which issues were of the most interest and importance to the actual respondents in this study. A more in-depth study of the intention of private forest owners to adopt exotic tree species based on these results could examine further the reasoning behind the importance awarded to different factors and how the factors may influence an actual decision to implement. Additionally, because the results of this study suggest that private forest owners may refrain from adopting exotics primarily because they perceive an economic risk, the potential influence of different economic factors and incentives could be further investigated.

Conclusions

The majority of private forest owners in Sweden desire increasing forest growth however not through the adoption of exotic tree species. The interest in such practices seems guided by perceptions of how well the species perform with respect to the production of forest products rather than environmental or recreational concerns. However, there is a need among private forest owners for increased information because a majority of these owners did not possess sufficient knowledge regarding the exotics nor about the ways in which they can increase forest growth. The intention to adopt the exotics exhibits the following order of preference: larch, hybrid aspen, Sitka spruce and lodgepole pine.

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References

Ajzen I (2005) Attitudes, personality, and behaviour, 2nd edn. Open University Press, Maidenhead

Andersson M, Gong P (2010) Risk preferences, risk perceptions and timber harvest decisions: an empirical study of nonindustrial private forest owners in northern Sweden. For Policy Econ 12(5):330–339. doi:10.1016/j.forpol.2010.02.002

Anon (2006) På väg mot ett oljefritt Sverige. Kommissionen mot oljeberoende [Swedish], (Swedish)

Anon (2010a) Focus on forestry: Increased profitability through increased growth. Focus on Forestry campaign pamphlet, JustNu

Anon (2010b) Kraftsamling skog: Verktygslåda för ökad lönsamhet i familjeskogsbruket. Kraftsamling skog [Swedish]

Arano KG, Munn IA (2006) Evaluating forest management intensity: a comparison among major forest landowner types. For Policy Econ 9(3):237–248. doi:10.1016/j.forpol.2005.07.011

Beach RH, Pattanayak SK, Yang J-C, Murray BC, Abt RC (2005) Econometric studies of non-industrial private forest management: a review and synthesis. For Policy Econ 7(3):261–281. doi:10.1016/s1389-9341(03)00065-0

Bergseng E, Vatn A (2009) Why protection of biodiversity creates conflict: some evidence from the Nordic countries. J For Econ 15(3):147–165. doi:10.1016/j.jfe.2008.04.002

Blennow K, Sallnäs O (2002) Risk perception among non-industrial private forest owners. Scand J For Res 17:472–479

Bohlin F, Roos A (2002) Wood fuel supply as a function of forest owner preferences and management styles. Biomass Bioenergy 22(4):237–249. doi:10.1016/s0961-9534(02)00002-8

Christersson L (1996) Future research on hybrid aspen and hybrid poplar cultivation in Sweden. Biomass Bioenergy 11(2–3):109–113. doi:10.1016/0961-9534(96)00014-1

Elfving B, Ericsson T, Rosvall O (2001) The introduction of lodgepole pine for wood production in Sweden: a review. For Ecol Manage 141(1–2):15–29. doi:10.1016/s0378-1127(00)00485-0

Engelmark O, Sjöberg K, Andersson B, Rosvall O, Ågren GI, Baker WL, Barklund P, Björkman C et al (2001) Ecological effects and management aspects of an exotic tree species: the case of lodgepole pine in Sweden. For Ecol Manage 141(1–2):3–13. doi:10.1016/s0378-1127(00)00498-9

Fahlvik N, Johansson U, Nilsson U (2009) Skogsskötsel för ökad tillväxt. Faktaunderlag till MINT-utredningen. Swedish University of Agricultural Sciences [Swedish]

Favada IM, Kuuluvainen J, Uusivuori J (2007) Optimal timber stock in Finnish nonindustrial private forests. For Policy Econ 9(5):527–535. doi:10.1016/j.forpol.2006.03.002

Hawkins DI, Mothersbaugh DL, Best RJ (2007) Consumer behaviour: building market strategy. McGraw-Hill/Irwin series in marketing, 10th edn. McGraw-Hill/Irwin, New York

Ingemarson F, Lindhagen A, Eriksson L (2006) A typology of small-scale private forest owners in Sweden. Scand J For Res 21: 249–259

Joshi S, Arano KG (2009) Determinants of private forest management decisions: a study on West Virginia NIPF landowners. For Policy Econ 11(2):118–125. doi:10.1016/j.forpol.2008.10.005

Karacic A (2005) Production and ecological aspects of short rotation poplars in Sweden. Doctoral thesis, Swedish university of agricultural sciences, Uppsala, Sweden

Karlman M (2001) Risks associated with the introduction of Pinus contorta in northern Sweden with respect to pathogens. For Ecol Manage 141(1–2):97–105. doi:10.1016/s0378-1127(00)00492-8

Karlman L (2010) Genetic variation in frost tolerance, juvenile growth and yield in russian larches: Implications for use in Sweden. Doctoral thesis, Swedish university of agricultural sciences, Umeå, Sweden

Karlsson B (2007) Sitka- och Douglasgran: alternativ för ett nytt klimat. vol 17. Skogforsk [Swedish]

Karppinen H (2005) Forest owners' choice of reforestation method: an application of the theory of planned behaviour. For Policy Econ 7(3):393–409. doi:10.1016/j.forpol.2003.06.001

Knight DH, Baker WL, Engelmark O, Nilsson C (2001) A landscape perspective on the establishment of exotic tree plantations: lodgepole pine (Pinus contorta) in Sweden. For Ecol Manage 141(1–2):131–142. doi:10.1016/s0378-1127(00)00496-5

Koontz TM (2001) Money talks but to whom? Financial versus nonmonetary motivations in land use decisions. Soc Nat Resour 14(1):51–65

Larsson S, Lundmark T, Ståhl G (2009) Möjligheter till intensivodling av skog: Slutrapport från regeringsuppdrag Jo 2008/1885. (Swedish)

Larsson-Stern M (2003) Aspects of hybrid larch (Larix x eurolepis Henry) as a potential tree species in southern Swedish forestry. Licenciate, Swedish university of agricultural sciences, Alnarp

Lidestav G, Ekström M (2000) Introducing gender in studies on management behaviour among non-industrial private forest owners. Scand J For Res 15(3):378–386

Lindkvist A, Mineur E, Nordlund A, Nordlund C, Olsson O, Sandström C, Westin K, Keskitalo ECH (2012) Attitudes on intensive forestry. An investigation into perceptions of increased production requirements in Swedish forestry. Scand J For Res 27(5):438–448

Lönnstedt L, Svensson J (2000) Non-industrial private forest owners' risk preferences. Scand J For Res 15(6):651–660

Nordlund A, Westin K (2011) Forest values and forest management attitudes among private forest owners in Sweden. Forests 2: 30–50

Pallant J (2007) SPSS survival manual: a step by step guide to data analysis using SPSS for Windows (version 15), 3rd edn. Open University Press, Maidenhead

Rämö AK, Järvinen E, Latvala T, Toivonen R, Silvennoinen H (2009) Interest in energy wood and energy crop production among Finnish non-industrial private forest owners. Biomass Bioenergy 33(9):1251–1257. doi:10.1016/j.biombioe.2009.05.013

Rogers EM (2003) Diffusion of innovations, 5th edn. Free press, New York

Skogsstyrelsen (2009) Regler om användning av främmande trädslag. Swedish Forest Agency, Jönköping [Swedish]

Statistics Sweden (2008) Statistical yearbook of forestry 2008. Official statistics Sweden and the Swedish forest agency, Jönköping

Tabachnick BG, Fidell LS (2006) Using multivariate statistics. 5, rev. edn. Allyn and Bacon, Boston

Tengberg F (2005) A production comparison between Sitka spruce (Picea sitchensis) and spruce (Picea abies). Master thesis, Swedish university of agricultural sciences, Alnarp, Sweden

Young J, Watt A, Nowicki P, Alard D, Clitherow J, Henle K, Johnson R, Laczko E et al (2005) Towards sustainable land use: identifying and managing the conflicts between human activities and biodiversity conservation in Europe. Biodivers Conserv 14(7):1641–1661. doi:10.1007/s10531-004-0536-z